Soviet-era science, translated into English

Reports of the Academy of Sciences of the USSR

PHYSICAL CHEMISTRY

1962

SovietRxiv

View the original and related papers at https://sovietrxiv.org/items/ru-196201.64594

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.

SovietRxiv

Figure 1. Surface tension of binary alkali-silicate melts.

Figure 1: Figure 1. Surface tension of binary alkali-silicate melts.

Abstract

Full Text

Reports of the Academy of Sciences of the USSR
1962. Volume 145, No. 3

PHYSICAL CHEMISTRY

A. A. Appen and S. S. Kayalova

SURFACE TENSION OF ALKALI-SILICATE MELTS

(Presented by Academician P. A. Rebinder on 23 III 1962)

Among binary glass-forming alkali-silicate systems, the surface tension (σ) of melts of Li_2O—SiO_2, Na_2O—SiO_2, and K_2O—SiO_2 has now been studied ($^{1-6}$). Of these, the Na_2O—SiO_2 system has been studied in greater detail. Until now, σ for rubidium and cesium silicate melts had remained unknown. We have measured σ of binary alkali-silicate melts at Me_2O oxide contents from 16 to 45 mol.% and have determined the effect of successive additions of a second alkali oxide on the surface tension of the systems Li_2O—SiO_2, Na_2O—SiO_2, and K_2O—SiO_2. Surface tension was measured by an improved drop-weight method (^{3}). By this method it is possible to determine σ with sufficient accuracy for melts having viscosities not exceeding 3000 poise. Good reproducibility of the measurements is observed; the experimental error is 1-2%.

Fig. 1. Surface tension of binary alkali-silicate melts. 1 –our data (1300°, drop-weight method); 2 –data of Shartsis and Spinner (1300°, cylinder-pull method); 3 –data of S. I. Popelya, O. A. Esin (1100°, maximum bubble pressure method); 4 –data of Parmeli et al. (1350°, maximum bubble pressure method).

Surface tension of melts of binary systems. To determine the surface tension, previously prepared binary glasses of specified composition were used. The experimental data are presented in Fig. 1. For comparison, the results of investigations by other authors are also given there. As can be seen, the drop-weight method gives results that agree well with data obtained by different methods.

The surface tension of melts of binary systems of equimolecular composition decreases sharply with increasing radius of the alkali ion, i.e., in the series Li → Na → K → Rb → Cs. At the same time, an increase in the concentration of alkali ions in the melt has different effects on σ and depends on the nature of the

SovietRxiv

Fig. 2. Dependence of the surface tension of the systems Rb_2O—SiO_2 and Cs_2O—SiO_2 on temperature

Figure 2: Fig. 2. Dependence of the surface tension of the systems Rb_2O—SiO_2 and Cs_2O—SiO_2 on temperature

oxide. The surface tension of lithium and sodium silicate melts increases in this case, whereas that of potassium, rubidium, and cesium melts decreases. Cesium-silicate melts, even in their high-silica region, at very high viscosities, have a small value of σ (about 170 erg/cm^2). When the Cs_2O content is 44%, the surface tension becomes equal to 120 erg/cm^2. The lithium melt of equimolecular composition exhibits a value of σ almost three times higher (340 erg/cm^2).

A change in temperature has little effect on the surface tension of alkali-silicate systems. From the example of rubidium and cesium melts (Fig. 2, Table 1), it is evident that raising the temperature by 100° causes a decrease of σ of the melt by 1-2%. The temperature coefficient $\Delta\sigma/\Delta t$ of rubidium and cesium melts is negative; its absolute value increases with increasing alkali concentration.

Table 1

Surface tension and temperature coefficient of surface tension of melts in the systems Rb_2O—SiO_2 and Cs_2O—SiO_2

Composition, mol. %	Composition, mol. %	σ, erg/cm^2	σ, erg/cm^2	σ, erg/cm^2	$\Delta\sigma/\Delta t$, erg/cm^2 · °C	Composition, mol. %	Composition, mol. %	σ, erg/cm^2	σ, erg/cm^2	$\Delta\sigma/\Delta t$, erg/cm^2 · °C
Rb_2O	SiO_2	1400°	1300°	1200°		Cs_2O	SiO_2	1400°	1300°	
17	83	197.1	200.1	–	−0.03	16	84	163.8	166.1	−0.023
20	80	188.8	192.7	–	−0.039	20	80	162.5	165.1	−0.026
24	76	183.5	188.0	–	−0.045	32	68	–	144.3	–
32	68	170.9	173.4	175.1	−0.025	44	56	–	120.5	–
40	60	–	146.3	155.0	−0.087					

The surface tension of melts with a high content of rubidium and cesium oxides changes noticeably during the experiment, owing to the strong volatility of these oxides. Therefore it was not possible to determine the influence of temperature on σ for cesium silicate melts containing 32 and 44% Cs_2O.

Fig. 2. Dependence of the surface tension of the Rb_2O—SiO_2 and Cs_2O—SiO_2 systems on temperature

Influence of a second alkali oxide on surface tension. The introduction of additions of a second alkali oxide into silicate systems, as is known, has a special

SovietRxiv

Fig. 3. Effect of additions of a second alkali oxide on the surface tension of lithium, sodium, and potassium silicate melts (1300°)

Figure 3: Fig. 3. Effect of additions of a second alkali oxide on the surface tension of lithium, sodium, and potassium silicate melts (1300°)

influence on many properties. Maxima or minima appear on the property curves (the "two-alkali effect" or neutralization effect (^{7})).

It remained unknown whether a similar effect is also observed for surface tension. Additions of second alkali oxides were introduced into two-component glasses $16.7\,\mathrm{Me_2O} \cdot 83.3\,\mathrm{SiO_2}$, where $\mathrm{Me_2O}$ represents $\mathrm{Li_2O}$, $\mathrm{Na_2O}$, $\mathrm{K_2O}$.

To obtain homogeneous melts, the glass powder with an addition of the carbonate of the corresponding oxide was thoroughly mixed in a mortar and remelted twice.

The oxides Me_2O, in terms of their effect on the surface tension of lithium, sodium, and potassium silicate melts, can be divided into two groups. The first group includes Li_2O and Na_2O, which, when introduced into the melt, only slightly increase its surface tension (Fig. 3). The values of surface tension in this case deviate little from the additivity rule and can approximately be calculated in advance (8). The second group includes K_2O, Rb_2O, and Cs_2O. When they are introduced into the melt, a sharp decrease in surface tension is observed. The concentration curves σ—C have a concave shape. The greatest lowering of the surface tension of the melts is caused by additions of cesium oxide.

Fig. 3. Effect of additions of a second alkali oxide on the surface tension of lithium, sodium, and potassium silicate melts (1300°).

It should be noted that additions of one and the same surface-active oxide (K_2O, Rb_2O, Cs_2O) in high concentrations (50 mol. %) give almost identical values of surface tension, regardless of σ of the initial melt. Additions of potassium oxide lower the surface tension of all three initial melts to 205-215 erg/cm^2, rubidium oxide to 180-187 erg/cm^2, and cesium oxide to 138-146 erg/cm^2. No "two-alkali effect" was found on the σ—C curves.

Institute of Silicate Chemistry
Academy of Sciences of the USSR

Received
22 III 1962

CITED LITERATURE

1. E. W. Washburn, E. E. Libman, *Univ. Illinois Bull. Including Eng. Exp. Stat. Bull.*, Ser. No. 140, 21, No. 33, 51 (1924).

2. C. W. Parmelee, K. C. Lyon, C. G. Harman, *Univ. Illinois Bull.*, 36, 81, June 6 (1939).

3. A. A. Appen, *Optical-Mechanical Industry*, No. 3, 7 (1936).

4. A. A. Appen, K. A. Shishov, S. S. Kayalova, *ZhFKh*, 26, No. 8, 1131 (1952).

5. S. I. Popel, O. A. Esin, *ZhNKh*, 2, issue 3, 632 (1957).

6. L. Shartsis, S. Spinner, *J. Res. Nat. Bur. Stand.*, 46, No. 5, 385 (1951).

7. *Glass Technology*, edited by I. I. Kitaygorodskii, Moscow, 1961, pp. 43, 79.

8. A. A. Appen, *ZhFKh*, 26, issue 9, 1399 (1952).

Note: Figure translations are in progress. See original paper for figures.

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.